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ONION SMUT: A DISEASE NEW TO BRITAIN.

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THE occurrence of Onion Smut in Britain is of importance not only on account of the serious nature of the disease itself but as a warning for the need of continual alertness with respect to the introduction of new diseases and the possibility of this being brought about by the use of contaminated seed.

Onion Smut is caused by the fungus *Urocystis cepulae*, Frost. The original wild host of this fungus is not known with certainty, but for the last fifty years it has been the cause of serious disease in the Eastern States of America, and it is usually regarded as of American origin. In Europe isolated outbreaks of Onion Smut have been reported from France, Germany and Denmark, but no record of its occurrence in England has been published. Massee deals with Onion Smut in his work "Diseases of Cultivated Plants and Trees" (1910), but he does not state that the fungus had been recorded as appearing in this country, and it is well known that he included in this volume several diseases not found in Britain. In his subsequent work, "Mildews, Rusts and Smuts" (1913), which is admittedly a British Flora, *Urocystis cepulae*, is not mentioned.

An extensive literature on Onion Smut is to be found in American publications. The disease commenced to be troublesome about 1870, and the first accurate account with a description of *Urocystis cepulae* was published by Farlow in 1877. A particularly full and careful account by R. Thaxter will be found in the Report of the Connecticut Agricultural Experiment Station for 1889. Since that date many bulletins and papers,

mostly concerned with control methods, have been published, and a general account will be found in all modern American text books.

With regard to the eradication of the disease, the great difficulty lies in the impossibility of satisfactorily disinfecting contaminated soil. The spores are very long lived, and soil badly contaminated, unless specially treated, is rendered useless for onion growing for many years. For this reason the cultivation of onions over thousands of acres of valuable ground in Connecticut had to be given up.

British Outbreaks.—The history of the outbreaks in Britain is as follows:—Diseased specimens of onions were submitted to the Board from a private garden near Northampton in the beginning of June, 1918. It was at once apparent that the plants were attacked by *U. cepulae*, and a visit was paid to the locality by two of the Board's officers in order to ascertain the extent of the affected area and the amount of damage which had been caused. The bed occupied by the onions proved to be small, and the total number of plants affected was not great—10 to 15 per cent. Many of these, however, were attacked severely and were completely crippled. The owner stated that he had observed the disease the previous season but was not successful in discovering its identity; on its reappearance, however, in 1918, he submitted specimens to the Board. The 1918 bed was in immediate proximity to the infected plot of 1917. The owner was advised carefully to remove and burn all affected plants and to abandon onion growing on the affected soil. Although onions had been cultivated for many years, the disease had not been noted previous to 1917. The introduction of Smut was therefore probably due to the use of contaminated seed.* The seed was bought locally, but efforts to trace the original source of supply were not successful.

The occurrence of the outbreak was at once made public. It was notified to the Board's Plant Disease Sub-Committee and to the honorary correspondents for the Plant Disease Survey. A Press notice was also issued warning gardeners, allotment holders, and others to be on their guard against the

* It is necessary to maintain the distinction between "contamination" and "infection." "Contamination" signifies that the fungus or fungal spores are *upon* or *amongst* the seeds, whilst "infection" would imply that the fungus had effected an entrance into the seed, which, in the present instance, is not the case.

presence of a new onion malady. As a result of this action a very large number of onion plants suffering from various diseases, especially *Macrosporium parasiticum* following *Peronospora*, were forwarded to the Board's Advisory Department, but no specimens affected with Smut were received. Since some uncertainty had been expressed with regard to the previous existence of the disease in England, a number of circular letters were sent to growers, inspectors, advisory biologists, etc., with regard to evidence on this point. With the exception of the two cases mentioned below, no evidence was forthcoming.

The two letters giving information of a positive character were from Dr. Wm. G. Smith, of the East of Scotland College of Agriculture, and Mr. S. P. Mercer, Acting Adviser in Agricultural Botany at Armstrong College, Newcastle-on-Tyne. Dr. W. G. Smith stated that a Smut fungus had occurred in young leeks and onions (especially the former) in some allotments near Edinburgh in 1912. The fungus was not, however, determined with certainty, and no record was published. The disease had not been observed before that date and no fresh cases had occurred. Dr. Smith kindly forwarded specimens preserved in spirit and the fungus proved to be the true Onion Smut *U. cepulae.*

Mr. S. P. Mercer in a detailed report showed that the disease was present in several gardens in Northumberland. He pointed out that it had been observed in 1914 and that its occurrence was noted in the Report of the Adviser in Agricultural Botany (Mr. W. B. Mercer) for 1914-15, but this report was not published. Being listed in the volume by Massee, cited above, the disease was not regarded as new to Britain. Leeks were stated to have been the first attacked and these have always shown greater susceptibility than onions. In 1918 Smut appeared in several new gardens in widely separated localities. An examination of the garden infected in 1914 failed to reveal the presence of Smut, but it should be noted that the examination was made late in the season, when attacked plants, had there been any, would probably have died and disappeared. Mr. Mercer had all the cases under strict observation and has in hand a number of trials with soil fungicides.

Further inquiries and careful observations were continued during the remainder of the season, as far as possible throughout the whole country, but no further outbreaks were reported.

Since it had been demonstrated in America that onion seed was at times liable to be contaminated with Smut spores (Ann. Report, Mass. Agric. Expt. Sta., 1910, pp. 164–7), it appeared possible that Smut was being introduced into this country with foreign seed. Fifty-two samples of American seed which was about to be sown at Kew were therefore tested for the presence of spores. Although in several cases resting spores of Onion Mildew were found, no evidence that the samples were contaminated with Smut was obtained.

Description of the Disease.—In the early stages of attack Onion Smut shows itself as dark opaque spots or streaks on the leaves. The streaks are at first covered by the skin of the leaf, but this is soon ruptured by the fungus within, and a sooty, powdery mass of spores is exposed. The spore-mass readily falls out or is blown away. In Figure 1 a mass of spores, still *in situ*, is seen in the upper part of the outer leaf on the left. This spore-mass formerly extended to the base of the bulb, but in the lower part it has almost entirely fallen away. It is from the presence of the soft, sooty mass of spores that the group of Smut fungi receive their name. Spore-masses form in the inner as well as in the outer leaves, and the outer scales of the bulb itself may also be affected in the same way.

The spores fall from the plants and contaminate the soil. Thaxter has estimated that a smutted onion plant, if of large size, may produce between one and two million spores. Examined with the microscope, the spores are of the compound type usually termed "spore-balls," and characteristic of the genus *Urocystis*. They consist of one, or rarely two, large dark spores (12–16 μ diam.) surrounded by a number of small, paler, sterile cells. The entire spore-balls measure 17-24 μ in diameter.

Onion Smut attacks seedling onions whether sown in spring or autumn. Its effect on the plant varies considerably. In bad cases the seedlings are killed outright, but in milder attacks they survive, though they are often severely crippled. White onions, especially White Lisbon, appear to suffer most. With regard to weather, favourable growing conditions, especially during the critical period of infection, probably assist the plant in overcoming the attack. In a hot, dry season, when the vigour of the host plant is reduced, the disease is more fatal.

Method of Infection.—Although the disease first shows itself externally in the form of dark areas on the leaves, the fungus entered the plant much earlier in its career. It was shown by

FIG. 1.—PLANTS AFFECTED WITH ONION SMUT.
Left: Showing an open fissure in the outer leaf of the bulb from which the bulk of the black spore mass has fallen out. A portion of the mass of spores is seen opposite S.
Right: A more severely diseased and crippled plant.

Thaxter that the plants are only attacked when quite young. Actual infection takes place below the ground level, and is probably confined to the first leaf. The mycelium produced develops within the tissues of the seedling, spreading upwards, and subsequently invading other leaves and producing the spore-masses described above. It will be observed, therefore, that the method of infection in Onion Smut, though comparable to that occurring in certain other Smut fungi, is different from that found in most leaf diseases (*e.g.*, mildews and rusts). The spores are unable to infect the green leaves above ground. It is particularly fortunate that this subterranean infection is confined to quite young seedlings, since it enables " sets " and seedlings raised in clean soil to be planted on contaminated land without fear of their contracting the disease.

Spread of the Disease and Vitality of Spores.—Onion Smut is distributed by any means which conveys the spores from one area to another. The bulk of the spore-mass falls to the ground on which the crop is grown, but, as the spores are very light, a certain number may be distributed by wind, though being produced so near the soil level they are probably not blown very great distances. Insects also may carry the spores. Flea Beetles were observed by Thaxter as swarming over the diseased leaves and apparently feeding on the spores, and these beetles are well known to travel long distances in search of food. In addition to the natural agencies mentioned, the disease may be spread by tools and implements, and also by the feet of workers conveying contaminated soil from one area to another. These means of distribution, being controllable, should be carefully avoided.

Although the fungus does not penetrate the seed and is thus not conveyed *in* it as is the case with some Smut fungi, it is quite possible for seed to become mixed with spores if grown in districts where Smut is plentiful. It is probable that the European outbreaks are directly or indirectly attributable to the use of such contaminated seed.

In common with many soil fungi, the spores of Onion Smut may retain their vitality for many years. It was formerly thought that a 5-year rotation would be sufficient to starve out the disease, but this proved quite erroneous. Thaxter mentions a case, apparently well authenticated, where bad outbreaks occurred in a field after twelve years, and it is probable that the spores may remain alive for a much longer period.

Control.—1. *Prevention of Spread.*—To prevent distribution of the spores and further contamination of the soil, it is absolutely essential to pay strict attention to the following points :—

(*a*) All diseased plants should be carefully dug up and destroyed by fire. This should be done as soon as the black streaks indicating the presence of the fungus and the formation of spores are visible, and before the spores are discharged. On no account should diseased plants be consigned to the rubbish or manure heap or allowed to decay on the ground.

(*b*) It is of the utmost importance also that the soil on which the smutted crop was produced, and all soil known to be contaminated with spores, should be confined to its present area, and not allowed to be carried to other beds or other gardens. Wind and rain may hinder this to a certain extent, but if the boots of those working on infected soil are properly brushed, and all tools carefully cleaned, the risk of spread will be reduced to a minimum.

2. *Suspension of Onion and Leek Growing on Affected Land.*—In view of American experience it is folly to attempt to starve out the disease by means of ordinary rotations. The case of a bad outbreak in Connecticut after a lapse of twelve years is apparently well authenticated, and one of the latest American text-books (Hall and Stevens, 1913) states that there is no record of soil once smutted having become clean. Sowing onions on affected land must, therefore, be discontinued. Leeks are if anything more susceptible to Smut than onions, so that the cultivation of this crop, and, for the sake of precaution, of shallots also, should be confined to soil free from contamination.

3. *Transplanting and the Use of "Sets."*—Although it is impossible to raise clean seedlings on contaminated soil it has been proved that seedlings raised in clean soil may be transplanted to land infested with spores without fear of their becoming infected. The fungus can only enter the plants whilst they are very young, and when once this stage is passed they may be transplanted to any soil with safety. For the same reason onion "sets" may be used. With regard to leeks, there is at present no definite evidence on this point, and until tests have been made it will be wise not to transplant leeks to affected ground.

It will be observed that the above system of cultivation forms an exception to the general rule enunciated under "2."

In the case of Britain, however, the amount of contaminated land is so small that it is hardly necessary to resort to the transplanting method, especially since it possesses an element of risk in that ungerminated seed or very young seedlings, still liable to attack, are apt to be accidentally carried with the older seedlings.

4. *Fungicides.*—The use of fungicides is resorted to in America when it is necessary to sow onions on land known to be affected, and the treatment has been successful in reducing the amount of disease. In the early days lime and sulphur were much recommended, but more recently formaldehyde has been advocated. In both cases the fungicide is applied to the drills. Various strengths are employed, but as no substance has been discovered which secures complete immunity to the disease, and as in this country there is no necessity to sow seed on affected land, details need not be given here.

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